9.1 General

This chapter describes the requirements for impoundments, including the following biological treatment processes.

a. Stabilization ponds

b. Aerated lagoons

Additionally, this chapter describes the requirements for use of hydraulic control release lagoons for effluent disposal.

A guide to provisions for lagoon design is the EPA publication Design Manual – Municipal Wastewater Stabilization Ponds, EPA-625/1-83-015.

9.1.1 Applicability

In general, impoundments, ponds and aerated lagoons are most applicable to small and/or rural communities where land is available at low cost and minimum secondary treatment requirements are acceptable. Additionally, these units are being used in decentralized wastewater treatment systems, such as surface spray irrigation (see Chapter 16) and subsurface drip dispersal (see Chapter 17). Advantages include potentially lower capital costs, simple operation, and low O&M costs.

9.1.2 Definitions

"**Director**" means the Director of the Division of Water Resources, Tennessee Department of Environment and Conservation.

"**Division**" means the Division of Water Resources, Tennessee Department of Environment and Conservation.

"**Fault**" means a fracture or a zone of fractures in any material along which strata on one side have been displaced with respect to that on the other side.

"**Floodplain**" means the lowlands and relatively flat areas adjoining inland waters, including flood prone areas, which are inundated by a flood. The "100-year floodplain" refers to a floodplain which is subject to a one percent or greater chance of flooding in any given year from any source.

"**Impoundment**" a structure designed to hold treated and/or untreated wastewater, esp. ponds and lagoons.

"**Karst**" means a specific type of topography that is formed by dissolving or solution of carbonate formations, such as limestone or dolomite; it is characterized by closed contour depressions or sinkholes, caves, sinking and reappearing streams, and/or underground conduit drainage flow.

"**Seismic impact zone**" means an area with a ten percent or greater probability that the maximum horizontal acceleration in lithified earth materials, expressed as a fraction of the earth's gravitational pull will exceed 0.10g in 250 years.

"**Unstable area**" means a location that is susceptible to natural or human-induced events or forces capable of impairing the integrity of some or all of the impoundment's structural components responsible for preventing releases from the impoundment. Unstable areas can include poor foundation conditions, areas susceptible to mass movements, and Karst terrains.

9.2 Engineering Report

In addition to the requirements in Chapter 1, the engineering report must include an assessment of the hydrogeological characteristics of the site that meets the requirements of these design criteria. This report shall be submitted prior to submission of the final construction plans and specifications. The hydrogeological portion of the engineering must:

1. Be prepared and certified by a qualified geologist who is registered with the State of Tennessee as required for such persons at T.C.A. § 62-36-102 or a qualified engineer who is registered with the State of Tennessee as required for such persons at T.C.A. Title 62, Chapter 2.
2. Be based on an analysis of existing data (e.g., well drillers' logs) and site-specific soil borings and drillers' logs or other subsurface investigations. The soil borings performed must be of such number, locations, and depths to sufficiently provide a complete and accurate description of relevant subsurface conditions.
3. Include a subsurface investigation using the Seismic Refraction Method in accordance with ASTM D-5777-00(2011)e1.
4. Include, but not necessarily be limited to, the following information:
   (i) A description of the soil sampling and analytical procedures used including, but not necessarily limited to, a characterization of the soils underlying the site providing, at a minimum:
      (a) Unified soil classifications;

(b) The saturated hydraulic conductivities of undisturbed samples of soils underlying the site that is to be used in meeting soil buffer requirements;

(c) The saturated hydraulic conductivity of remolded samples of soils taken from the site which are to be used in meeting liner and cover requirements; and

(d) A description of the soil sampling and analytical procedures used;

(ii) A tabulation of water table elevations (if encountered within the limits of drillings) measured at the time borings were performed and at least two additional measurements over a period of at least one week so as to allow water elevations to stabilize. If an estimation of the seasonal high water table cannot be made utilizing this data and other existing information, then the Division may require water table elevations to be collected over a period up to one year.

(iii) A boundary plat locating soil borings with accurate horizontal and vertical controls which are tied to a permanent on-site bench-mark (reference elevation may be site specific). The plat must include the boundary of the proposed fill areas;

(iv) A potentiometric map of the uppermost aquifer (if such can be determined by information obtained within the limits of drilling) based on stabilized water elevations;

(v) A description of local ground water recharge and discharge features in the vicinity of the proposed impoundment and, if the Division deems appropriate, a description of the regional ground water regime;

(vi) The locations of any springs and existing and abandoned wells within a one mile radius;

(vii) The locations of public water supply system intakes within a two mile radius; and

(viii) A narrative summary and analysis of geological and hydrological evaluations performed as they relate to the suitability of the site for an impoundment, and addressing in particular compliance with appropriate standards of these criteria.

5. Undisturbed soil samples for hydraulic conductivity shall be collected in thin walled Shelby tubes per ASTM D-1587. The hydraulic conductivity shall be determined in accordance with ASTM D-5084.
6. Remolded soil samples for hydraulic conductivity shall be re-compacted in accordance with ASTM D-698 or ASTM D-1557. The hydraulic conductivity shall be determined in accordance with ASTM D-5084.

7. The report must include:
    (i) A comprehensive environmental site assessment that includes an evaluation of the quality of ground water beneath the proposed impoundment. At a minimum, the applicant must provide analytical information for all constituents specified in regulations adopted by the board. The requirement for a comprehensive environmental assessment shall apply to new impoundments as well as for expansions, modifications, or new units for existing approved impoundments; and
    (ii) Proof satisfactory to the Division that the geological formation of the proposed site and the design of the proposed impoundment are capable of containing the wastes so that the requirements in Rule 0400-45-6-.05 are not exceeded.

8. Prior to excavation, all bore holes drilled or dug during subsurface investigation of the site, piezometers, and abandoned wells which are either in or within 100 feet of the areas to be filled must be backfilled with a bentonite slurry or other sealant approved by the Division to an elevation at least ten feet greater than the elevation of the lowest point of the base of the impoundment (including any liner), or to the ground surface if the site will be excavated less than ten feet below grade.

9.3 <u>Design Loadings</u>

9.3.1 Stabilization ponds

Stabilization ponds are facultative and are not artificially mixed or aerated. Mixing and aeration are provided by natural processes. Oxygen is supplied mainly by algae.

Design loading shall not exceed 30 pounds BOD per acre per day on a total pond area basis and 50 pounds BOD per acre per day to any single pond (from Middlebrooks, E.J., et al., 1982. *Wastewater Stabilization Lagoon Design, Performance and Upgrading*, McMillan Publishing Co., New York, NY).

9.3.2 Aerated Lagoons

An aerated lagoon may be a complete-mix lagoon or a partial-mix aerated lagoon. Complete-mix lagoons provide enough aeration or mixing to maintain solids in suspension. Power levels are normally between 20 and 40 horsepower per million gallons. The partial-mix aerated lagoon is designed to permit accumulation of settleable solids on the lagoon bottom, where they decompose anaerobically. The power level is normally 4 to 10 horsepower per million gallons of volume.

BOD removal efficiencies normally vary from 80 to 90 percent, depending on detention time and provisions for suspended solids removal.

The aerated lagoon system design for minimum detention time may be estimated by using the following formula; however, empirical data should be used if available.

Equipment typically required for aerated lagoons includes the following: lining systems, inlet and outlet structures, hydraulic controls, floating dividers and baffles, aeration equipment. Every system should have at least three cells in series with each cell lined to prevent adverse groundwater impacts. Many states have design criteria that specify design loading, the hydraulic residence time, and the aeration requirements (EPA, Wastewater Technology Fact Sheet. *Aerated Partial Mix Lagoons*). Pond depths range from 1.8 to 6 m (6 to 20 ft), with 3 m (10 ft) the most typical (the shallow depth systems usually are converted facultative lagoons). Detention times range from 10 to 30 days, with 20 days the most typical (shorter detention times use higher intensity aeration). The design of aerated lagoons for BOD removal is based on first-order kinetics and the complete mix hydraulics model. Even though the system is not completely mixed, a conservative design will result. The model commonly used is:

$$C_e = C_o/[1 + (K_T)(t)/n]^n$$

where:

C_e = effluent BOD

C_o = influent BOD

K_T = temperature dependent rate constant

K_{20} = rate constant at 20° C

K_{20} = 0.276 d^{-1} at 20° C = temperature coefficient (1.036)

$K_T = K_{20}^{(T-20)}$

T = temperature of water

d = depth

t = total detention time in system

n = number of equal sized cells in system

Detention times in the settling basin or portion of a basin used for settling of solids should be limited to two days to limit algae growth.

The reaction rate coefficient for domestic sewage that includes significant quantities of industrial wastes, other wastes, and partially treated sewage should be determined experimentally for various conditions that might be encountered in the aerated ponds. Conversion of the reaction rate coefficient to temperatures other than 20 degrees C should be according to the following formula:

$K_T = K_{20}\, 1.036^{(T-20)}$ (T = temperature in degrees C)

The minimum equilibrium temperature of the lagoon should be used for design of the aerated lagoon. The minimum equilibrium temperature should be estimated by using heat balance equations, which should include factors for influent wastewater temperature, ambient air temperature, lagoon surface area, and heat transfer effects of aeration, wind, and humidity. The minimum 30-day average ambient air temperature obtained from climatological data should be used for design.

Additional storage volume shall be considered for sludge storage in partial mix in aerated lagoons.

Sludge processing and disposal should be considered.

9.3.3 Proprietary Processes

Proprietary process designs will be considered, however, the engineering report should justify process selection and sizing with sufficient data from two or more similar capacity installations with similar flow characteristics and effluent discharge requirements.

9.4 Special Details

9.4.1 General

9.4.1.1 Location

a. Distance from Habitation

A pond site should be located as far as practicable from habitation or any area that may be built up within a reasonable future period, taking into consideration site specifics such as topography, prevailing winds, and forests. Buffer zones shall be in accordance with 9.4.1.7.

b. Prevailing Winds

If practical, ponds should be located so that local prevailing winds will be in the direction of uninhabited areas. Preference should be given to sites that will permit an unobstructed wind sweep across the length of the ponds in the direction of the local prevailing winds.

c. Surface Runoff

Location of ponds in watersheds receiving significant amounts of runoff water is discouraged unless adequate provisions are made to divert storm water around the ponds and protect pond embankments from erosion.

d. Water Table

The effect of the ground water location on pond performance and construction must be considered.

e. Ground Water Protection

Ground Water Protection's main emphasis should be on site selection and liner construction. Proximity of ponds to water supplies and other facilities subject to contamination and location in areas of porous soils and fissured rock formations should be critically evaluated to avoid creation of health hazards or other undesirable conditions. The possibility of chemical pollution may merit appropriate consideration. Test wells to monitor potential ground water pollution may be required and should be designed with proper consideration to water movement through the soil as appropriate.

An approved system of ground water monitoring wells or lysimeters may be required around the perimeter of the pond site to facilitate ground water monitoring. The use of wells and/or lysimeters will be determined on a case-by-case basis depending on proximity or water supply and maximum ground water levels. This determination will be at the site approval phase.

A routine ground water sampling program may be required to be initiated prior to and during the pond operation based upon the hydrologic study.

f. Floodwaters

Pond sites shall not be constructed in areas subject to 100-year flooding, or the ponds and other facilities shall be protected by dikes from the 100-year flood.

9.4.1.2 **Location with respect to Scenic Rivers**

An impoundment shall not be located within two miles of the center of a Class II scenic river, nor within two miles of the center of such a river in an adjacent upstream county, notwithstanding the fact that the river is not designated as a scenic river in the upstream county, if the river is designated as a Class II scenic river in the adjacent downstream county; and provided further that the facility shall not be located within five miles of the center of the Buffalo River in Lewis County.

The river segments that are Class II scenic rivers are those that have been designated by the General Assembly in Tenn. Code Ann. §11-13-104. At this time those are:

1. Blackburn Fork -- That segment downstream from a point one and one-half (1 ½) miles downstream from the county road at Cummings Mill to its confluence with Roaring River.
2. Buffalo River -- The entire river, except that portion which lies within Wayne, Perry, Humphreys and Lewis counties.
3. Collins River -- That segment which lies within the Savage Gulf natural scientific area.
4. Duck River -- That segment of the Duck River beginning at Iron Bridge Road at river mile 136.4 extending continuously to a point upstream to the boundary of Marshall County at river mile 173.7.
5. Harpeth River -- The entire river except that segment lying north of Highway 100 and south of Interstate 40 in Davidson County; and except those segments located in Cheatham, Dickson and Williamson counties.
6. Roaring River -- That segment downstream from a point two (2) miles downstream from State Route 136, to its confluence with the Cordell Hull Lake.
7. Spring Creek -- That segment between State Highway 136 and Waterloo Mill, and that segment downstream from the Overton-Jackson county line to its confluence with Roaring River.

9.4.1.3 **Karst Topography**

If a facility is proposed in an area of highly developed karst topography (i.e., sink holes, caves, underground conduit flow drainage, and solutionally enlarged fractures) the applicant must demonstrate to the satisfaction of the Division that relative to the proposed facility siting:

1. There is no significant potential for collapse;
2. The ground water flow system is not a conduit flow which would contribute significant potential for collapse or which would cause significant degradation to the ground water; and
3. Location in the karst topography area will not cause any significant degradation to the local ground water resources.

The above referenced demonstration may require the installation of piezometers, the developing of a potentiometric-surface map of ground water, conducting geophysical surveys, dye tracing or other specific requirements deemed necessary by the Division to evaluate the proposed site to his satisfaction.

9.4.1.4 **Fault areas**

Impoundments shall not be located within 200 feet (60 meters) of a fault that has had displacement in Holocene time unless the design engineer provides a detailed rationale showing that an alternative setback distance of less than 200 feet (60 meters) will prevent damage to the structural integrity of the impoundment and will be protective of human health and the environment.

9.4.1.5 **Seismic Impact Zones**

Impoundments shall not be located in seismic impact zones, unless the design engineer provides a detailed rationale showing that all containment structures, including liners, are designed to resist the maximum horizontal acceleration in lithified earth material for the site.

9.4.1.6 **Unstable areas**

The design engineer for all impoundments located in an unstable area must demonstrate that engineering measures have been incorporated into the design to ensure that the integrity of the structural components of the impoundment will not be disrupted. The design engineer must consider the following factors, at a minimum, when determining whether an area is unstable:

1. On-site or local soil conditions that may result in significant differential settling;
2. On-site or local geologic or geomorphologic features; and
3. On-site or local human-made features or events (both surface and subsurface).

9.4.1.7 **Buffers**

Impoundments must be located, designed, constructed, operated, and maintained such that the fill areas are, at a minimum:

1. 100 feet from all property lines;
2. 500 feet from all residences, unless the owner of the residential property agrees in writing to a shorter distance;
3. 500 feet from all wells determined to be down gradient and used as a source of drinking water by humans or livestock;
4. For impoundments of 1 million gallons or less, 200 feet from the normal boundaries of springs, streams, lakes, (except that this standard shall not apply to any wet weather conveyance nor to bodies of water constructed and designed to be a part of the facility);
5. For impoundments of greater than 1 million gallons, 1,000 feet from the normal boundaries of springs, streams, lakes, (except that this standard shall not apply to any wet weather conveyance nor to bodies of water constructed and designed to be a part of the facility; and
6. A total site buffer with no constructed appurtenances within 50 feet of the property line.

9.4.1.8 Pond Shape

The shape of all cells should be such that there are no narrow or elongated portions. Round, square, or rectangular ponds should have a length to width ratio near 1:1 for complete mix ponds. Rectangular ponds with a length not exceeding three times the width are considered most desirable for complete mix aerated lagoons. However, stabilization ponds should be rectangular with a length exceeding three times the width, or be baffled to ensure full utilization of the basin. No islands, peninsulas, or coves are permitted. Dikes should be rounded at corners to minimize accumulations of floating materials.

9.4.1.9 Recirculation

Recirculation of lagoon effluent may be considered. Recirculation systems should be designed for 0.5 to 2.0 times the average influent wastewater flow and include flow measurement and control.

9.4.1.10 Flow Measurement

The design shall include provisions to measure, total, and record the wastewater flows to meet permit requirements.

9.4.1.11 Level Gauges

Pond level gauges should be located on outfall structures or be attached to stationary structure for each pond.

All impoundments must have remote water level monitoring capable of providing a continuous, 24-hour per day, 365 day, record of impoundment levels accurate to within 0.125 inches.

9.4.1.12 Pond Dewatering

Sufficient pumps and appurtenances should be available to facilitate draining of individual ponds in cases where multiple pond systems are constructed at the same elevation or for use if recirculation is desired.

9.4.1.13 Control Building

A control building for laboratory and maintenance equipment should be provided.

9.4.1.14 General Site Requirements

The pond area shall be enclosed with an adequate fence to keep out livestock and discourage trespassing and be located so that travel along the top of the dike by maintenance vehicles is not obstructed. A vehicle access gate of width sufficient to accommodate mowing equipment and maintenance vehicles should be provided. All access gates shall be provided with locks. Cyclone-type fences, 5 to 6 feet high with 3 strands of barbed wire, are desirable, with appropriate warning signs required.

9.4.1.15 Provision for Sludge Accumulation

Influent solids, bacteria, and algae that settle out in the lagoons will not completely decompose and a sludge-blanket will form. This can be a problem if the design does not include provisions for removal and disposal of accumulated sludge, particularly in the cases of anaerobic stabilization ponds and aerated lagoons. The design should include an estimate of the rate of sludge accumulation, frequency or sludge removal, methods of sludge removal, and ultimate sludge handling and disposal.

9.4.2 Stabilization Ponds

9.4.2.1 Depth

The primary (first in a series) pond depth should not exceed 6 feet. Greater depths will be considered for polishing ponds and the last ponds in a series of 4 or more.

9.4.2.2 Influent Structures and Pipelines

a. Manholes

A manhole should be installed at the terminus of the interceptor line or the force main and should be located as close to the dike as topography permits; its invert should be at least 6 inches above the maximum operating level of the pond to provide sufficient hydraulic head without surcharging the manhole. Trash collection as part of the final manhole or headworks shall be provided unless the system is limited to STEP/STEG influent.

b. Influent Pipelines

The influent pipeline can be placed at zero grade if provisions to clean or flush are included. The influent pipeline shall not impede circulation.

c. Inlets

Influent and effluent piping should be located to minimize short-circuiting and stagnation within the pond and maximize use of the entire pond area.

Multiple inlet discharge points shall be used for primary cells larger than 10 acres.

All gravity lines should discharge horizontally onto discharge aprons. Force mains should discharge vertically up and shall be submerged at least 2 feet when operating at the 1-foot depth.

d. Discharge Apron

Provision should be made to prevent erosion at the point of discharge to the pond.

9.4.2.3 Interconnecting Piping and Outlet Structures

Interconnecting piping for pond installations shall be valved or provided with other arrangements to regulate flow between structures and permit variable depth control.

The outlet structure can be placed on the horizontal pond floor adjacent to the inner toe of the dike embankment. A permanent walkway from the top of the dike to the top of the outlet structure is required for access.

The outlet structure should consist of a well or box equipped with multiple-valved pond drawoff lines. An adjustable drawoff device is also acceptable. The outlet structure should be designed so that the liquid level of the pond can be varied from a 3.0-5.0 foot depth in increments of 0.5 foot or less. Withdrawal points shall be spaced so that effluent can be withdrawn from depths of 0.75 foot to 2.0 feet below pond water surface, irrespective of the pond depth.

The lowest drawoff lines should be 12 inches off the bottom to control eroding velocities and avoid pickup of bottom deposits. The overflow from the pond shall be taken near but below the water surface. A two-foot deep baffle may be helpful to keep algae from the effluent. The structure should also have provisions for draining the pond. A locking device should be provided to prevent unauthorized access to level control facilities. An unvalved overflow placed 6 inches above the maximum water level shall be provided.

Outlets should be located nearest the prevailing winds to allow floating solids to be blown away from effluent weirs.

The pond overflow pipes shall be sized for the peak design flow to prevent overtopping of the dikes.

9.4.2.4 Minimum and Maximum Pond Size

No pond should be constructed with less than ½ acre or more than 40 acres of surface area.

9.4.2.5 Number of Ponds

A minimum of three ponds, and preferably four ponds, in series should be provided (or baffling provided for a single call lagoon design configuration) to insure good hydraulic design. The objective in the design is to eliminate short circuit

9.4.2.6 Parallel/Series Operation

Designs, other than single ponds with baffling, should provide for operation of ponds in parallel or series. Hydraulic design should allow for equal distribution of flows to all ponds in either mode of operation.

9.4.3 Aerated Lagoons

9.4.3.1 Depth

Depth should be based on the type of aeration equipment used, heat loss considerations, and cost, but should be no less than 7 feet. In choosing a depth, aerator erosion protection and allowances for ice cover and solids accumulation should be considered.

The minimum operating depth should be sufficient to prevent growth of aquatic plants and damage to the dikes, bottom, control structures, aeration equipment, and other appurtenances.

a. Controlled-Discharge and Flow-Through Facultative Treatment Pond Systems

The maximum water depth should be 6 feet (1.8 m) in primary cells. Greater depths in subsequent cells are permissible although supplemental aeration or mixing may be necessary.

b. Aerated Treatment Pond Systems

The design water depth should be 10 to 15 feet (3.0 m to 4.6 m). This depth limitation may be altered depending on the aeration equipment, waste strength, and climatic conditions.

9.4.3.2 Influent Structures and Pipelines

The same requirements apply as described for facultative systems, except that the discharge locations should be coordinated with the aeration equipment design.

9.4.3.3 Interconnecting Piping and Outlet Structures

a. Interconnecting Piping.

The same requirements apply as described for facultative systems.

b. Outlet Structure.

The same requirements apply as described for facultative systems, except for variable depth requirements and arrangement of the outlet to withdraw effluent from a point at or near the surface. The outlet shall be preceded by an underflow baffle.

9.4.3.4 Number of Ponds

Not less than three basins should be used to provide the detention time and volume required. The basins should be arranged for both parallel and series operation. A settling pond with a hydraulic detention time of 2 days at average design flow must follow the aerated cells, or an equivalent of the final aerated cell must be free of turbulence to allow settling of suspended solids.

9.4.3.5 Aeration Equipment

A minimum of two mechanical aerators or blowers shall be used to provide the horsepower required. At least three anchor points should be provided for each aerator. Access to aerators should be provided for routine maintenance which does not affect mixing in the lagoon. Timers will be required.

9.5 Pond Construction Details

9.5.1 Liners

Impoundments must have a liner designed to function for the estimated life of the site. The liner must be:

1. A composite liner consisting of two components: (1) the upper component must consist of a minimum 60-mil flexible membrane liner (FML), and (2) the lower component must consist of at least a two-foot layer of compacted soil with a hydraulic conductivity of no greater than 10^{-7} cm/sec. The FML component must be installed in direct and uniform contact with the compacted soil component.
2. Constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure due to pressure gradients, physical contact with the waste to which they are exposed, climatic conditions, the stress of installation, and the stress of daily operation;
3. Placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift;
4. Installed to cover all surrounding earth likely to be in contact with the waste;
5. Of sufficient strength and durability to function for the life of the facility; and

6. Sloped such that, excluding excavation side slopes, the slope of the liner shall not exceed 1 vertical to 4 horizontal.

9.5.2 Compacted soil component

The compacted soil component of the composite liner shall be as follows:

1. The compacted soil liners shall be free of sharp objects and be compatible with supporting soils and with leachate expected to be generated.
2. Admixtures (i.e., cement, bentonite, etc.) and special construction techniques may be used to improve the properties of the compacted soil liner provided that:
   a) In no case shall the liner thickness be less than two (2) feet; and
   b) The modified liner shall achieve equivalent or superior performance to requirements of the minimum performance standard as described in this subparagraph.
   c) Soil used in constructing the pond bottom (not including the seal) and dike cores shall be relatively incompressible and tight and compacted between 2 and 4 percent above the optimum water content to at least 95 percent Standard Proctor Density.
   d) The pond bottom shall be as level as possible at all points. Finished elevations shall not be more than 3 inches (75 mm) from the average elevation of the bottom.

9.5.3 Other Liners

Other liners that have been successfully used are soil cement, gunite, and asphalt concrete. The performance of these liners is highly dependent on the experience and skill of the designer. The use of these types of liners will require prior approval by the Division.

9.5.4 Protection from deterioration

The liner should not be subject to deterioration in the presence of the wastewater. The geotechnical recommendations should be carefully considered during pond liner design. Test wells may be required by the Division, especially when non-domestic wastes are involved.

If the ponds are going to remain empty for any period of time, consideration should be given to the possible effects on the soil liners from freezing and thawing during cold weather or cracking from hot, dry weather. Freezing and thawing will generally loosen the soil for some depth. This depth is dependent on the depth of frost penetration.

There may be special conditions when reinforced membranes should be considered. These are usually considered where extra tinsel strength is required. The membrane liner material should be compatible with the wastewater in the ponds such that no damage results to the liner. PVC liners should not be used where they will be exposed directly to sunlight.

No equipment should be allowed to operate directly on the liner.

The manufacturer’s representative shall be on site supervising the installation during all aspects of the liner placement.

An independent inspector shall be on site to monitor and inspect all aspects of the installation.

9.6 Pond Construction

9.6.1 General

Ponds are often constructed of either a built-up dike or embankment section constructed on the existing grade, or they are constructed using a cut and fill technique. Dikes and embankments shall be designed using the generally accepted procedures for the design of small earth dams. - Consideration should also be given to slope stability and seepage through and beneath the embankment and along pipes. Dikes should be constructed of relatively impervious soil and compacted to at least 95 percent Standard Proctor Density to form a stable structure. Vegetation and other unsuitable materials should be removed from the area where the embankment is to be placed.

Construction and placement of the soil liner should be inspected by a qualified inspector. The inspector should keep records on the uniformity of the earth liner material, moisture contents, and the densities obtained and submit these records to the Division upon completion of construction.

9.6.2 Top Width

The minimum recommended dike top width should be 12 feet on tangents and 14 feet on curves to permit access of maintenance vehicles. The minimum inside radius of curves of the corners of the pond should be 35 feet.

9.6.3 Slopes

Inner and outer dike slopes should not be steeper than 1 vertical to 3 horizontal (1:3). Flatter slopes have the disadvantage of added shallow areas being conducive to emergent vegetation. Grading around the dikes shall be sufficient to prevent surface runoff from entering the ponds.

9.6.4 Freeboard

There should be sufficient freeboard to prevent overtopping of the dike from wave action and strong winds. Minimum freeboard should be 2 feet.

9.6.5 Erosion Control

Erosion control should be considered for the inside slopes of the dike to prevent the formation of wavecut beaches in the dike slope. In the event that earth liners or membrane liners with earth cover are used, consideration should be given to erosion protection directly beneath aeration units. If the currents are strong enough, considering the type of material used for the earth cover, erosion pads may be necessary beneath the aeration units. Erosion control should also be considered wherever influent pipes empty into the pond. If a grass cover for the outer slopes is desired, they should be fertilized and seeded to establish a good growth of vegetative cover. This vegetative cover will help control erosion from runoff.

The dikes shall have a covered layer of at least 4 inches (100 mm), of fertile topsoil to promote establishment of an adequate vegetative cover wherever riprap is not utilized. Prior to prefilling adequate vegetation shall be established on dikes from the outside toe to 2 feet (0.6 m) above the pond bottom on the interior as measured on the slope. Perennial-type, low-growing, spreading grasses that minimize erosion and can be mowed are most satisfactory for seeding on dikes. In general, alfalfa and other long-rooted crops should not be used for seeding since the roots of this type are apt to impair the water-holding efficiency of the dikes.

Consideration should also be given to protection of the outer slopes in the event that flooding occurs. The erosion protection should be able to withstand the currents from a flood.

Riprap or some other acceptable method of erosion control is required as a minimum around all piping entrances and exits. For aerated cells the design should ensure erosion protection on the slopes and bottoms in the areas where turbulence will occur. Additional erosion control may also be necessary on the exterior dike slope to protect the embankment from erosion due to severe flooding of a watercourse.

9.6.6 Utilities and Structures Within Dike Sections

Pipes that extend through an embankment should be installed with anti-seep collar materials in order to minimize water leakage around the pipe through the embankment. Backfill should be with relatively impermeable flowable fill material. No granular bedding material should be used. Cutoff collars should be used as required. No gravel or granular base should be used under or around any structures placed in the embankment within the pond. Embankments should be constructed at least 2 feet above the top of the pipe before excavating the pipe trench.